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# The First 15 Months of Transluminal Abdominal Aortic Aneurysm Management: A Single Centre Experience

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***Objectives:*** *To assess the early experience with the transfemorally placed modular endovascular MinTec graft (TPEG) for abdominal aortic aneurysm (AAA).*
***Design:*** *One single centre prospective evaluation of the endograft procedure as well as early postoperative results.*
***Setting:*** *An academic teaching hospital.*
***Patients:*** *30 consecutive patients treated during a period of 15 months.*
***Results:*** *Peri- and postoperative morbidity and mortality were evaluated according to the recommendations of the Ad Hoc Committee on Reporting Standards. The endograft procedure was successful in 28 patients (93.4%); two patients (6.6%) needed conversion into open conventional y-graft replacement; one patient died 36 days following intervention from multiple organ failure. Another patient died from pancreatitis unrelated to the implantation. Endoleaks were treated by "overstenting" or distal extension of the endografts, but conversions were unnecessary. Five severe adverse events were noted in four patients.*
***Conclusions:*** *TPEG is a feasible but technically demanding procedure, requiring both surgical techniques and catheter skills. The potential for less operative morbidity and simpler aneurysm management compared to conventional open surgery may be present. Close follow-up of patients is necessary to understand the development and treatment of endoleaks.*

*Key Words: Transfemorally placed endografts; Abdominal aortic aneurysm; Endovascular procedure; Stent-grafts.*

## Introduction

Since repair of abdominal aortic aneurysm (AAA) was first described,[1] surgical graft replacement rather than simple aneurysm observation has evolved over the last four decades.[2]

Perioperative complication rates as high as 5–10% and mortality rates of between 3–5% and 10–14% are reported.[3–5]

The risk of active surgical intervention has to be weighed against the risk of rupture, against a background of limited life expectancy and a variety of comorbid conditions. With the introduction of endoluminal aneurysm management, a more aggressive approach towards repair might be warranted and will probably influence future treatment policies.

In contrast to other publications[6,7] this report documents a single centre experience with a modular thin-walled polyester graft, mounted on a self-expanding Nitinol stent. The time frame of 15 months was chosen because the device used was available only for a limited interval and was subsequently withdrawn from the market.

## Patients and Methods

From March 1995 to the end of May 1996, a consecutive series of 30 patients underwent transfemorally placed endovascular grafts (TPEGs) for infrarenal abdominal aortic aneurysm (AAA).

The endograft used (Mialhe-Stentor®, MinTec Inc., Freeport, Grand Bahama; distributed in Austria by CrossTec, Vienna) is a self-expanding, modular, multi-segmental endoprosthesis, based upon a Nitinol framework in a tubular zig-zag configuration. The stent frame is covered by a woven, medium-permeability 0.1 mm polyester fabric cover. The implants

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For the endovascular study group, Vienna.

are available in a straight (tube) and bifurcated configuration. The y-graft consists of two components, which are introduced sequentially and assembled intraluminally.

At the trailing part of the main aortic section there is a short branch of 10 mm diameter, situated contralaterally to the vascular access site, into which the second extension graft limb is inserted. The devices are available in lengths ranging from 143 to 163 mm and diameters of 20–26 mm. The extension grafts vary in diameter between 10 and 12 mm and are available in different lengths ranging from 60 to 100 mm. The tubular aortic graft is available in diameters ranging from 20 to 26 mm and in lengths from 80 to 100 mm.

The data were collected prospectively and no endografts were implanted prior to the study. All patients were aware of the experimental nature of the procedure, and gave informed consent to participate in the study, which had been approved by the local ethics committee.[8]

Each implant had to be tailored individually and therefore only patients awaiting elective procedures were eligible. All patients presented with aneurysms that by current practice standards required repair. A spiral computed tomography (CT) scan and intra-arterial arteriography with a calibrated catheter were performed to size the aneurysm accurately.

The median age of the 28 men and two women was 70.0 years (range: 54.6–79.6 years). All patients receiving a stent-graft are numbered in consecutive order, which is referred to throughout the article. No patients were excluded from this series (Table 1).

Patients showed the typical comorbidities in peripheral arterial disease (46.6% current smokers; 10% diabetic metabolic state; 30% hyperlipidemic state; 66.6% arterial hypertension (RR>160/90 mmHg); 46.6% coronary artery disease; 56.6% chronic obstructive pulmonary disease; 29.2% cerebrovascular disease; and note that in various patients more than one risk factor was present, Table 1). According to the ASA classification, 43.3% were in stage III and 56.7% in stage IV, respectively (Table 1). Aneurysms were graded into four categories, with respect to their involvement of the iliac and hypogastric arteries (Table 2). Type "A" were aneurysms involving only the infrarenal aorta, presenting with a distinct distal cuff. Type "B" were aneurysms of the infrarenal aorta with involvement of the aortic bifurcation. Type "C" were aneurysms of the infrarenal aorta including enlargement of the proximal part of the common iliac arteries. Type "D" were aneurysms similar to type "C", but with additional involvement of the hypogastric arteries.

In accordance with other groups we adhere to the so-called "TEAM" approach,[6] where surgeons, interventional radiologists and angiologists work together in the operating suite.

All procedures were performed in the operating theatre using general anaesthesia and endotracheal intubation. The vascular surgical operating suite is equipped with an image intensifier and a radiolucent operating table. The patients were prepared and draped for a conventional "open" surgical procedure in the event of a failing endoluminal repair and subsequent conversion.

After gaining access to the femoral artery by direct exposure, on-table angiography was obtained to identify and mark the renal arteries and the aortic bifurcation. Systemic heparin was administered 100 IU/kg body weight, with exception of patient 15.

Fluoroscopic guidance was used to introduce the endograft into the aorta employing an 18F delivery sheath. The large-bore diameter necessitates a femoral cut-down at one side, whereas a percutaneous access in the contralateral side is feasible when a bifurcated graft is implanted.

The principles of vascular access, implant introduction, deployment and anchoring as well as completion of the procedure have been described by several investigators and seem to follow a common principle, but vary to some extent depending upon the specific implant used.[6,7,9–12]

After completion of the procedure an on-table angiogram was routinely performed. Prior to discharge, at 3 months, 6 months, 1 year and then biannually, a CT scan with contrast and an IV-angiography was obtained. In addition, patients were scheduled for a clinical examination as an outpatient whenever needed.

## Results

The mean diameter of the treated AAA was 5.7 cm (range: 4.5–8.0 cm). The average operative time was 234 min (range: 115–340 min), which seems similar to elective conventional open surgery.[13] During the first year of the study 22 patients underwent elective conventional open surgery for AAA, for which the average operating time was 243 min. Fluoroscopy time was 41.6 min (range: 11–98.4 min) and 235 ml (range: 110–400 ml) of contrast were used (Table 2). The Stentor-System allowed the implantation of endografts in the straight ($n = 12$) as well as the bifurcated configuration ($n = 18$). Tube graft implantations were shorter and needed less fluoroscopy time and less

**Table 1. Demographic data of the 30 patients undergoing AAA management with TPEG.**

| Patient | Age | Sex | Abdominal status | Cardiac function | Pulm fu | Renal function | Cerebrovascular disease | Clearance | ASA-score |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 54.6 | M | AE, 2× peptic ulcer perforation, peritonitis | Stable angina | COPD, mild | | | Y | 4 |
| 2 | 75.7 | M | CHE | Stable angina | COPD | | | Y | 4 |
| 3 | 68.9 | M | | CABG | | Obstruction, creatinine >2.0 | | Y | 3 |
| 4 | 65.0 | M | | | | | Carotid TEA | Y | 3 |
| 5 | 75.7 | M | Radical prostatectomy | Stable angina, AV-Block I | Emphysema | | | Y | 4 |
| 6 | 71.8 | M | AE with peritonitis | Stable angina, supravent. arrhythmia | | | | Y | 4 |
| 7 | 72.6 | M | | Stable angina, st. post MI | COPD | | | Y | 4 |
| 8 | 70.6 | M | Splenectomy, hiatal hernia correction | Stable angina, AV-Block I | COPD | Nephrolithiasis | | Y | 4 |
| 9 | 65.9 | M | | | | | | Y | 3 |
| 10 | 76.1 | M | | Left ventricular hypertrophy | COPD | | | Y | 4 |
| 11 | 64.4 | M | | | COPD | | | Y | 3 |
| 12 | 68.3 | M | Rectal extirpation, colostomy | | COPD | | 70% r ICA stenosis | Y | 4 |
| 13 | 71.3 | M | | | | Horseshoe kidney | r ICA occlusion | Y | 3 |
| 14 | 74.6 | M | | | COPD | | 50% I ICA stenosis | Y | 3 |
| 15 | 68.3 | M | | St. post CABG, AVR | COPD | | | N | 4 |
| 16 | 76.0 | M | CHE, rectal resection ×2, radical prostatectomy | Stable angina | | | | Y | 4 |
| 17 | 75.5 | M | | Stable angina, st post MI ×2 | COPD | | PRIND | Y | 4 |
| 18 | 76.9 | F | CHE, abd. Hysterectomy | Ventricular hypertrophy, arrhythmia | COPD, severe | Small left kidney | | N | 4 |
| 19 | 55.6 | M | | | | | Carotid TEA | Y | 3 |
| 20 | 73.2 | M | Gun-shot injury, peritonitis, several laparotomies | St. post MI, AV-Block, pacemaker | COPD | Nephrolithiasis | PRIND, st. p. cerebral tumour | N | 4 |
| 21 | 76.9 | M | CHE | Ventricular arrhythmia | | | | Y | 4 |
| 22 | 73.4 | M | | | | | | Y | 3 |
| 23 | 77.6 | M | | CABG, st. post MI | COPD | | | N | 4 |
| 24 | 57.0 | M | | St. post CABG ×2 | COPD | | | Y | 4 |
| 25 | 62.3 | M | Bilateral inguinal hernia | | | | | Y | 3 |
| 26 | 79.6 | F | | | | | | Y | 3 |
| 27 | 76.0 | M | | | COPD | | | Y | 3 |
| 28 | 68.5 | M | CHE, AE, inguinal hernia | CABG ×2, AVR, HTX | | Creatinine: >3.0 | | Y | 4 |
| 29 | 60.9 | M | | | COPD | | | Y | 3 |
| 30 | 67.5 | M | | | COPD, mild | | | Y | 3 |

Abdominal status: AE = appendectomy; CHE = open cholecystectomy.
Cardiac function: CABG = coronary artery bypass grafting; AVR = aortic valve replacement; MI = myocardial infarct; HTX = cardiac transplant.
Pulm fu: COPD = chronic obstructive pulmonary disease.
Cerebrovascular disease: carotid TEA = carotid thrombendarterectomy; ICA = internal carotid artery; PRIND = prolonged reversible ischaemic neurological deficit.
Clearance: Y = clearance for an open procedure; N = no clearance.

**Table 2. Technical data of the 30 procedures in 30 patients undergoing endovascular aneurysm management.**

| Patient | Graft | AAA-DM (sac)-cm | Prox neck (mm) | IMA | RII | LII | AAA type | Blood replacement | Anatomic difficulties | OR-time (min) | Fluoroscopy (min) | Contrast (ml) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Bif-Y | 4.9 | 50 | O | P | P | C | 0-0-0 | | 210 | 35.1 | 250 |
| 2 | Tube | 5.6 | 30 | O | P | P | A | 0-0-0 | | 140 | 29.4 | 250 |
| 3 | Tube | 5.7 | 10 | O | P | P | B | 0-0-0 | Inflammatory aneurysm | 200 | 36.0 | 110 |
| 4 | Bif-Y | 5.6 | 30 | O | P | P | B | 0-0-0 | | 240 | 42.0 | 220 |
| 5 | Bif-Y | 7.2 | 17 | P | P | P | B | 0-0-0 | | 255 | 38.0 | 250 |
| 6 | Tube | 4.5 | 30 | O | P | P | A | 0-0-0 | | 230 | 28.0 | 160 |
| 7 | Tube | 4.5 | 15 | O | P | P | A | 1-0-0 | | 205 | 24.0 | 200 |
| 8 | Tube | 5.0 | 18 | O | P | P | A | 0-0-0 | | 150 | 28.4 | 250 |
| 9 | Tube | 4.9 | 44 | P | P | P | A | 0-0-0 | Accessory renal artery | 105 | 17.3 | 110 |
| 10 | Bif-Y | 5.1 | 45 | O | P | P | C | 0-0-0 | | 195 | 33.0 | 260 |
| 11 | Tube | 4.9 | 20 | P | P | P | A | 0-0-0 | | 125 | 17.0 | 200 |
| 12 | Tube | 4.9 | 49 | P | P | P | A | 0-0-0 | Accessory renal artery | 120 | 20.6 | 120 |
| 13 | Tube | 4.8 | 30 | P | P | P | A | 1-0-0 | Horseshoe kidney | 210 | 29.0 | 180 |
| 14 | Bif-Y | 4.9 | 20 | P | P | P | B | 0-0-0 | | 240 | 62.0 | 240 |
| 15 | Bif-Y | 5.2 | 12 | O | P | P | C | 1-0-2 | | 257 | 43.0 | 400 |
| 16 | Bif-Y | 6.0 | 20 | O | P | P | B | 0-0-2 | | 245 | 48.0 | 250 |
| 17 | Bif-Y | 6.2 | 28 | O | P | P | B | 0-0-0 | | 190 | 62.0 | 150 |
| 18 | Bif-Y | 8.0 | 50 | O | P | P | B | 0-0-0 | | 240 | 67.0 | 155 |
| 19 | Bif-Y | 4.8 | 40 | O | P | O | D | 2-2-1 | Inflammatory aneurysm | 245 | 45.0 | 340 |
| 20 | Bif-Y | 6.5 | 18 | O | O | O | D | 0-0-0 | Accessory renal artery | 340 | 55.4 | 340 |
| 21 | Tube | 5.0 | 45 | O | P | P | A | 0-0-0 | | 186 | 11.0 | 135 |
| 22 | Bif-Y | 6.6 | 15 | O | P | P | B | 0-0-0 | | 240 | 59.4 | 200 |
| 23* | Bif-Y | 6.9 | 18 | O | P | P | B | n.a. | | 620 | 98.4 | 320 |
| 24 | Bif-Y | 6.5 | 25 | O | P/A | P | C | 0-0-2 | Accessory renal artery | 240 | 49.4 | 290 |
| 25 | Bif-Y | 6.0 | 50 | P | P | P | B | 0-0-0 | | 125 | 23.5 | 200 |
| 26 | Bif-Y | 6.5 | 27 | O | P | P | B | 0-0-0 | Accessory renal artery | 225 | 54.9 | 400 |
| 27 | Bif-Y | 5.5 | 62 | P | P | P | D | 0-0-0 | | 250 | 88.4 | 400 |
| 28* | Bif-Y | 5.7 | 22 | O | P | P | B | n.a. | | 780 | 88.0 | 400 |
| 29 | Tube | 5.5 | 28 | P | P | P | A | 0-0-0 | | 125 | 14.5 | 120 |
| 30 | Tube | 7.6 | 35 | O | P | P | A | 0-0-0 | | 115 | 12.0 | 125 |

(*) in patients marked the procedure was converted to open repair.
Graft: Tube = tubular graft; Bif-Y = bifurcated y-graft.
AAA types A–D, see "Methods" section.
IMA = inferior mesenteric artery; RII = right internal iliac artery; LII = left internal iliac artery; O = occluded; P = patent; A = aneurysmal.
Blood replacement: OR-ICU-surgical ward; n.a. = not applicable.

contrast (159 min; 22.3 min; 163 ml) than y-grafts (233 min; 50.3 min; 271 ml), the difference being statistically significant at the 0.005 level. Fig. 1 shows an artist's impression of the implantation of a tube graft, and Fig. 2 shows diagrammatically the implantation of a bifurcated graft. The need to catheterise the main trunk of the graft via the orifice of the contralateral graft limb to assemble the extension graft is clearly demonstrated.

*ASA classification and clearance for surgery*

ASA classification was routinely employed in all patients prior to surgery to assess the risk for anaesthesia.[14] The distribution of patients in the respective ASA classification is given in Table 1. At the beginning of our experience all patients undergoing TPEG had to be considered fit enough to undergo an open procedure as well. After the positive initial experience patients who were borderline for an open procedure (patients 15, 18, 20 and 23) were accepted as candidates for the endovascular operation (Table 1).

*Complex aneurysms*

Patients 3 and 19 presented with inflammatory aneurysms, proven by CT scan in both cases. In addition, ureter obstruction due to the inflammatory aneurysm was present in patient 3 (Fig. 1). Patient 13 presented with a horseshoe kidney with accessory renal arteries deriving from the aneurysm body. Five additional patients presented with accessory renal arteries (patients 9, 12, 20, 24 and 26) either adjacent to the aneurysm or originating from the aneurysm body (Table 2).

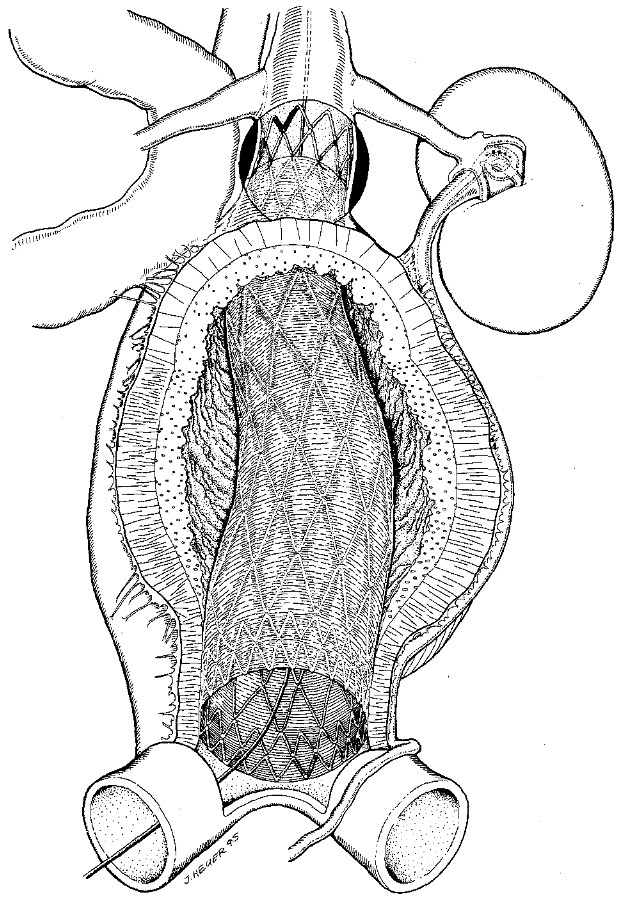


**Fig. 1.** Implantation of a straight tube graft. Note the thick wall of the aneurysm sac, as seen in inflammatory aneurysms. A catheter is placed in the obstructed left ureter (patient 3).

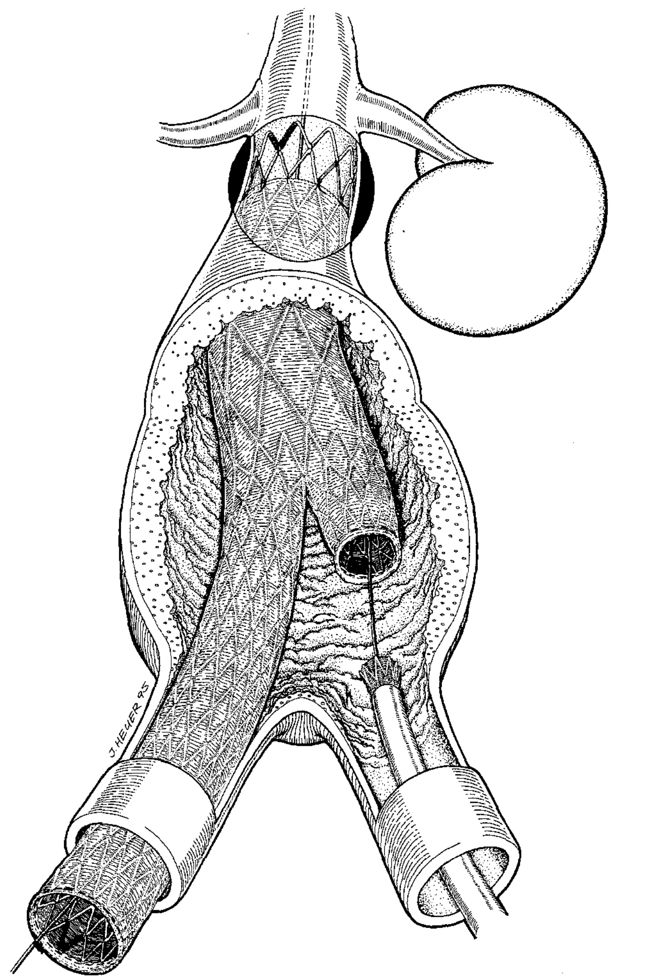


**Fig. 2.** Diagrammatic view of a bifurcated endograft during implantation. Note the proximal uncovered end of the device. The bifurcated graft needs catheterisation of the contralateral graft limb in order to deploy the extension graft as shown in the figure.

*Intensive care stay*

Every patient but one was admitted postoperatively to an ICU according to the ethics committee's recommendation for at least 12 h. The average admission time to the ICU was 21 h in patients with a successful TPEG procedure.

*Mortality*

The 30-day mortality was zero. However, patient 28 died in the same hospital stay after an ICU stay of 36 days, due to multiorgan failure and sepsis (see "Conversions"). Patient 19 died 188 days after successful implantation due to necrotising pancreatitis which was unrelated to the aneurysm management. The diagnosis was confirmed by post-mortem examination in both cases.

*Conversions*

In two patients the endovascular procedure had to be converted to open surgery. In patient 23 a bifurcated endograft was intended, but misplacement of the contralateral guide wire remained undetected until the extension graft was deployed. Endoluminal retrieval of the extension graft was thought to be impossible and the endograft was removed and an aortobifemoral y-graft implanted using conventional surgical techniques. Postoperatively, the patient developed multiorgan failure requiring circulatory, renal, and ventilatory support. After 38 days in the ICU and 68 days in hospital the patient was discharged in stable condition.

In patient 28, during the introduction and advancement of the main body of the endograft, incidental dissection of the iliac artery and the distal infrarenal aorta occurred. Partial re-entry of the device into the aortic lumen obscured the problem and the graft was fully assembled intramurally. Immediately after completion of the procedure, blockage of the endograft occurred. The diagnosis was confirmed through on-table angiography. Conventional repair using a bifurcated graft was performed, but the patient subsequently developed multiorgan failure and died of sepsis on the 36th postoperative day. The patient was on immunosuppression for a previous cardiac transplant. In both instances the rescue procedures were difficult to carry out, the overall combined operating time being 10 and 13 h, respectively (Table 2).

### *Extragraft flow*

After insertion of the endografts, nine primary endoleaks were observed after successful graft deployment (32.1%). Extragraft flow was defined according to White.[15] The same procedure was used to manage four leaks successfully either by placing an additional aortic stent-graft ($n=1$; patient 2; "over-stenting") or a distal iliac artery extension graft ($n=1$; patient 24), or by iliac artery banding ($n=2$; patients 20 and 27). Thus, in 82.1% (23/28) of the implantations the AAA was excluded. In the remaining five patients the leak was not detected ($n=2$; patients 12 and 13) or was considered minimal ($n=3$; patients 4, 5 and 16). Of the leaks, eight originated from the distal anastomoses (patients 2, 4, 12, 13, 16, 20, 24 and 27); whereas one was a proximal endoleak (patient 5). Secondary endoleaks have not been detected so far.

### *Incidental coverage of renal arteries*

In three patients (patients 15, 22 and 30), the proximal uncovered part of the stent-graft was incidentally placed over one renal artery orifice. This caused an infarction of the lower pole in patient 15. The renal arteries remained patent in all three patients during the follow-up of 6, 4 and 4.4 months respectively. No deterioration of renal function was noted in all these patients.

### *Intentional coverage of renal arteries*

In three patients (patients 12, 13 and 24) accessory renal arteries were occluded intentionally by the covered part of the graft. No patient experienced a clinically relevant deterioration of the kidney function. Two patients experienced silent kidney infarctions during follow-up (patients 12 and 13).

### *Transfusion requirements*

Patients 7 and 13 needed blood transfusions due to problems with haemostatic valves, patient 15 was implanted on active oral anticoagulant treatment, and patient 19 required local lysis and evacuation of a groin haematoma (see below). The two patients undergoing conversion procedures needed 6 and 10 units of blood respectively (patients 23 and 28). Therefore, 23 implantations were done without any blood replacement. The need for transfusion is shown in Table 2.

### *Reocclusions*

One graft limb occluded immediately following the procedure (patient 19). Local lysis of the graft via the left transbrachial route was successful, but a haematoma from the groin adjacent to the vascular access site had to be evacuated. After 3 months, the graft reoccluded and was again reopened by means of local lysis. One month later the left graft limb blocked again, leaving the patient with intermittent claudication until he died.

### *Bowel obstruction*

On postoperative day 6, one patient (patient 20) developed bowel obstruction due to paralytic ileus, and intestinal ischaemia was strongly suspected due to the complicated abdominal history (Table 1). Exploration was felt to be indicated, but was negative.

### *Postimplantation syndrome*

Pyrexia of unknown origin (up to 39 °C) developed in seven patients (patients 4, 6, 8, 10, 11, 14 and 21) which resolved spontaneously. Cultures taken at the time of implantation and during the immediate postoperative follow-up remained negative. Patients 1, 2 and 4 complained of back pain, which resolved spontaneously within the first postoperative week following treatment.

*Complications at the access sites*

At the femoral cut-down, two plaque ruptures were observed during the graft advancement (patients 7 and 12). After withdrawal of the sheath, local thromboendarterectomy and vein patch closure were performed. Following placement of bifurcated endografts, one local haematoma was treated conservatively (patient 27) and one pseudoaneurysm was successfully managed by ultrasound-guided compression (patient 24).

The adverse events are given according to the recommendations of the ad hoc Committee on reporting standards for lower extremity ischaemia[16] and are summarised in Table 3. Five severe adverse events have been recorded in four patients.

**Table 3. Adverse events following TPEG observed in 30 patients.***

| Adverse events | Number of events A mild | B moderate | C severe | |
|---|---|---|---|---|
| Systemic/remote | | | | |
| Respiratory failure | 0 | 2 | 0 | A = transient, not requiring ventilator; B = transient, requiring ventilator; C = permanent/death |
| Renal insufficiency | 0 | 2 | 0 | A = transient; B = transient, requiring dialysis; C = permanent, fatal |
| Sepsis | 0 | 0 | 1 | A = requiring drug therapy; B = requiring resuscitation; C = fatal |
| Multiple organ failure | 0 | 1 | 1 | A = requiring drug therapy; B = requiring resuscitation; C = fatal |
| Pyrexia of unknown origin | 1 | 7 | 0 | A = resolved without treatment; B = drug therapy required; C = operation required, fatal |
| Back pain | 0 | 3 | 0 | A = resolved without treatment; B = drug therapy required; C = fatal |
| Local/vascular | | | | |
| Leak; graft/vessel | 4 | 4 | 2 | A = observed, no therapy; B = required intervention, stenting; C = re-do operation, conversion |
| Damage access artery | 0 | 2 | 0 | A = observed no treatment; B = local treatment required; C = required extensive repair |
| Damage contralat. artery | 1 | 1 | 0 | A = observed no treatment; B = local treatment required; C = extensive vascular repair |
| Graft thrombosis | 0 | 1 | 0 | A = not corrected; B = required re-do; local lysis; C = limb loss |
| Blood transfusion | 0 | 7 | 0 | A = no transfusion given; B = blood transfusion required; C = fatal |
| Local/non-vascular | | | | |
| Haematoma | 0 | 0 | 1 | A = observed, resolved; B = aspirated; C = surgical drainage |

* Summarised according to R. Rutherford[16].

*Hospital stay*

After exclusion of the two patients (patients 23 and 28) who had an adverse course following open surgery, the postoperative length of stay in the 28 successful patients was a median of 6 days (range: 4–11 days).

*Follow-up*

Three patients have completed their 18-month follow-up, seven their 12-month and four their 6-month check-up; the remaining 16 patients have been observed for intervals of less than 6 months. All the endografts remained patent, with one exception (patient 19). The median postoperative follow-up is 7.6 months. No graft migrations, pseudoaneurysms, secondary leaks or embolic episodes have been detected. During follow-up, patient 1 developed unstable angina and underwent aortocoronary bypass grafting 11 months after endografting. In patient 9, a non-Hodgkin lymphoma was diagnosed 11 months postoperatively and the patient has currently completed the first cycle of chemotherapy. In patient 26, a pulmonary lesion was detected 3 months postoperatively, but the patient refused further investigation.

## Discussion

Open surgical repair is the standard treatment for AAA, but carries a mortality risk of between 1.4 and 6.5%.[3–5] As in other areas of surgery, the tendency towards less invasive techniques is inevitable. Advancement of an endograft from the groin into the infrarenal aorta is a less invasive endoluminal option, which might have an impact in improving the safety of AAA repair. The current technology was pioneered by J. Parodi and his colleagues and the first clinical cases were reported in 1991.[10,11,17,18] Bifurcated grafts can now be deployed either through a "pull-over" manoeuvre[9,12,19] or can be assembled within the aneurysm sac, but common to all variations is the concept of thin-walled grafts connected to stents.[20]

In our country patients who undergo open aneurysm surgery require an average postoperative hospital stay of 12–14 days, or even longer in complicated cases. TPEG seems to necessitate a much shorter length of stay, which seems to render the endograft procedure cost-effective, despite the expense for the procedure.[13]

The endograft procedure is potentially safe and simple. Complications requiring open conversion make subsequent surgery difficult[21] and time-consuming, requiring extensive blood replacement. The blood loss may be related to the heparin administration. In addition, the large amounts of contrast administered may contribute to acute renal impairment.[21] The combination of blood loss, renal failure, circulatory instability and the prolonged procedure results in a high mortality being reported in these patients.[21]

A major problem associated with endograft repair of aneurysms is ineffective exclusion of the aneurysm sac.[15] The reasons for this might be incomplete attachment between the graft at the proximal or distal end and the aortic wall. Defects in the endograft itself or at the connection sites between the different components may result in an endoleak. This may or may not be detected by on-table arteriography because the graft materials are thin and very porous, and therefore it takes time to seal. Extragraft flow present at the end of the procedure may disappear within several days. Persistent extragraft flow within the aneurysm sac following the procedure has to be considered a primary failure. It seems important to distinguish minor endoleaks, which will thrombose spontaneously, and major ones, which will generate continuous pulsatile pressure within the aneurysm sac, causing further growth of the aneurysm,[22] finally leading to rupture. Such leaks require treatment. It is not known whether thrombosed leaks remained sealed or have the potential to reoccur.[23]

Secondary endoleaks have not been observed, but the series is small with short follow-up.

To anchor an endograft securely, a proximal neck of at least 1.5 cm is required. Placing the proximal end of the stent over the origin of the renal arteries would increase the length of proximal attachment site,[24] but more experience is required.

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